

ATHLETIC ABILITY ASSESSMENT: A MOVEMENT ASSESSMENT PROTOCOL FOR ATHLETES

Ian McKeown, PhD^{1,2,3,5}Kristie Taylor-McKeown, PhD⁴Carl Woods⁶Nick Ball, PhD²

ABSTRACT

Background/Purpose: Movement ability is an often-overlooked component of sports science and sports medicine research and needs to be considered alongside the appraisal of physical fitness and performance characteristics. To achieve this, a standardised assessment tool is required. The purpose of this paper is to introduce a new method for assessing movement ability and present results for intra- and inter-rater reliability.

Methods: National level female football players (n = 17) were assessed using a novel movement assessment tool, the Athletic Ability Assessment (AAA). Athletes were assessed according to the scoring criteria by the primary researcher in real-time and via video on two separate occasions to estimate intra-tester reliability. Inter-tester reliability was estimated using the difference between five other testers' video-based scores.

Results: The intra-tester minimal detectable change (MDC) for the composite AAA score was 2.9 points (90% confidence limits; 2.3 – 4.2 points) (2.5%; 2.0 – 3.6%) with an intraclass correlation coefficient (ICC) of 0.97 (0.92 – 0.99). Inter-tester MDC for the composite AAA score was 2.8 points (2.5 – 3.3 points) (2.4%; 2.1 – 2.8%) with an ICC 0.96 (0.94 – 0.98). Individual exercise scores for the intra- and inter-tester show a similar range MDC of between 0.4 – 1.1 points and kappa statistic level of agreement between 0.32 – 0.77.

Conclusions: Results of the reliability analysis suggest high levels of agreement between scorers for total scores and provide reference values for minimal detectable changes using the AAA. The aim of the AAA is to become a reliable movement assessment protocol that addresses specific sporting populations. The reliability of AAA scoring established in this study is the first step in supporting the utilization of the AAA in future research.

Key words: Functional movement, reliability, screening

Level of evidence: 2b

¹ Strength and Conditioning, Australian Institute of Sport, Canberra, Australia

² National Institute of Sport Studies, University of Canberra, Canberra, Australia

³ Strength and Conditioning, Australian Capital Territory Academy of Sport, Canberra, Australia

⁴ Sports Science Department, Australian Capital Territory Academy of Sport, Canberra, Australia

⁵ Port Adelaide Football Club, Adelaide, Australia

⁶ School of Exercise and Health Sciences, Edith Cowan University, Joondalup, Western Australia, Australia

Approval for this study was granted from the Australian Institute of Sport Research Ethics Committee

CORRESPONDING AUTHOR

Ian McKeown
Port Adelaide FC
Alberton
South Australia 5015
Australia
E-mail: imckeown@pafc.com.au

INTRODUCTION

Athletes require a strong foundation in a diverse range of athletic qualities in order to tolerate the progressively advanced training loads and competitive demands of their chosen sport. The improvement of foundation movements that underpin these athletic qualities early in the athletes' development pathway is one of the key recommendations of long term athlete development models.^{1,2} The foundation movements typically involve variations of squatting, lunging, jumping, pushing, pulling and bracing.³⁻⁶ Typically these movements are objectively assessed using some form of functional movement assessment criteria in order to screen athletes for dysfunctional movement patterns in an attempt to alleviate injury risk through addressing incorrect movement patterns.⁷ The Functional Movement Screen (FMS™) by Cook⁷ is by far the most popular screening tool used to provide an objective assessment of movement in sports performance research and is typically synonymous with the term "functional movement".⁸⁻¹⁰ The FMS™, however, was developed as screening tool for determining if someone is safe to exercise.¹¹ The need still remains for a level of assessment that accounts for sporting demands and movement under load. To further highlight the need for an athletic assessment, a recent survey of sports performance practitioners working in high performance sport revealed that the majority of these practitioners preferred to implement their own version of movement assessment rather than the FMS™.¹² This suggests that the FMS™ protocol may not meet the perceived needs of the practitioner working in high performance sport.

McKeown has suggested that there are movements that underpin athletic performance which should be used in assessment of movement capabilities in athletes.¹² In order for movement assessment to be effective the assessment must not only assess dysfunction across a standardized set of movements, but also identify differences in performers ability to execute these movements. Questions have been raised over the ability of the FMS™ to characterize meaningful changes in movement quality over multiple testing sessions and the relationship of FMS™ scores and sports performance improvement.^{9,13,14} The FMS™ was originally developed to assess normal function of fundamental movement skills of

daily living.⁷ Sports performance requires more demanding fundamental movement ability in areas such as total body control under increasing load, single leg jumping and landing abilities, and other complex movement challenges that underpin sport performance. Practitioners therefore use tools they consider more appropriate for the athletic populations they are working with.¹² Practitioners may also feel the movements used in the FMS™ do not, in their experience, align adequately to their coaching approach and therefore would not be useful in informing coaching decisions. There is limited evidence to support the conjecture of these notions in the literature; however this study is the first step in the scientific process to present an alternate assessment of movement ability and discuss it's impact on subsequent physical performance and also training resilience. In order for the movement assessment process to be included in more performance science literature and considered in future research, alternative methods must be discussed and examined.

In this study the authors' propose an alternative assessment tool that addresses the need for movement assessment specific to athletic populations. The Athletic Ability Assessment (AAA) is not to be used as a clearance screen in order to begin training safely, as is the suggested use of the FMS™,¹¹ but as an assessment methodology that can be utilized as athletes travel along their sporting pathway and require increased movement competency under load and under greater levels of movement complexity. The assessment criteria presented in this study illustrate the first level of assessment on the continuum of athletic development; future assessment levels should be progressed accordingly. One of the key differences of the AAA is that the exercises used to assess functional movement are more closely aligned with the foundation movement skills underpinning sports performance in that particular environment,^{3,15} including the use of load and complexity of movement. These movements are still assessed in a way that highlights movement dysfunction, but have the advantage of providing a more focused exercise progression template that is well aligned to performance enhancement. In addition to the different exercises used in the movement assessment, the scoring system for each exercise is designed to examine the key components of each

movement individually. This provides more information of separate functional qualities across exercises. By examining key components such as trunk control, range of motion, and lower body alignment across a range of exercises, commonalities of dysfunction can be highlighted that provides more insightful feedback to inform the program prescription and coaching process.

The authors' propose that the AAA be used as an assessment tool for athlete profiling, as well as be used to assess changes in functional movement ability over time (by making multiple measurements on the same athlete following a training intervention). In order to confidently assess changes in an individual it is necessary to obtain an estimate of the measurement error that might arise solely from the tester(s). The specific objectives of this study were to determine the absolute error with one tester rating the same movements one week apart (intra-tester reliability) as well as determining the error associated with different testers scoring the same performance (inter-tester reliability). A secondary objective of this study is to investigate the differences between real-time assessment and video-based assessment using the same tester.

METHODS

National level female football players ($n = 17$) (mean \pm SD; 22 ± 4 y) completed the AAA as part of pre-season assessment for a semi-professional football team. Athletes were injury free at time of assessment (more than six months injury free) and were provided with a full description of the assessment protocol. Each athlete was scored by the primary researcher of this study who had over five years' experience of movement assessment scoring and is an experienced strength and conditioning coach currently accredited by the U.K. Strength and Conditioning Association (Accredited Strength and Conditioning Coach; ASCC) and the Australian Strength and Conditioning Association (Professional Coach; ASCA Pro structure). All other scorers ($n = 5$) were strength and conditioning professionals with at least 2 years' experience of movement assessment scoring and professionally accredited by the ASCA. This study was granted institutional research board ethics approval.

Details of the movements used in the assessment plus a rationale for each exercise are outlined in

Appendix 1. Each movement assesses trunk stability, hip, knee, ankle alignment, squat or lunge ability, and the ability to jump and land correctly. Many of the movements incorporate multiple elements.

Movements and the subsequent assessment points for each movement were chosen to expose deficiencies in foundational movement patterns required to train and perform competitively in sports.^{15,16,17} The scoring criteria consist of three main assessment points per exercise. Each assessment point is scored out of a possible three points, one being poor, unable to perform specific task; two being inconsistent performance of specific task or slight deviation from ideal; three being perfect performance of specific task in the coaching. The sum of the three assessment points comprises the score for each individual exercise. Maximum score per movement is nine. Separate scores are given for exercises performed unilaterally. The total of all the individual tests provides the composite score for each athlete. The composite score for the AAA is out of a possible 117 points.

Athletes performed the AAA protocol in sequential order as outlined in Appendix 1 and as illustrated in Figures 1 to 7. They were given specific instructions and demonstration on how to correctly perform each movement, including a verbal description of the scoring criteria verbatim from the scoring criteria in Table 1. Each athlete was familiar with the assessment criteria having gone through the process at least once previously. A short, five-minute dynamic warm up was performed prior to



Figure 1. *Prone hold*



Figure 2. *Side hold*

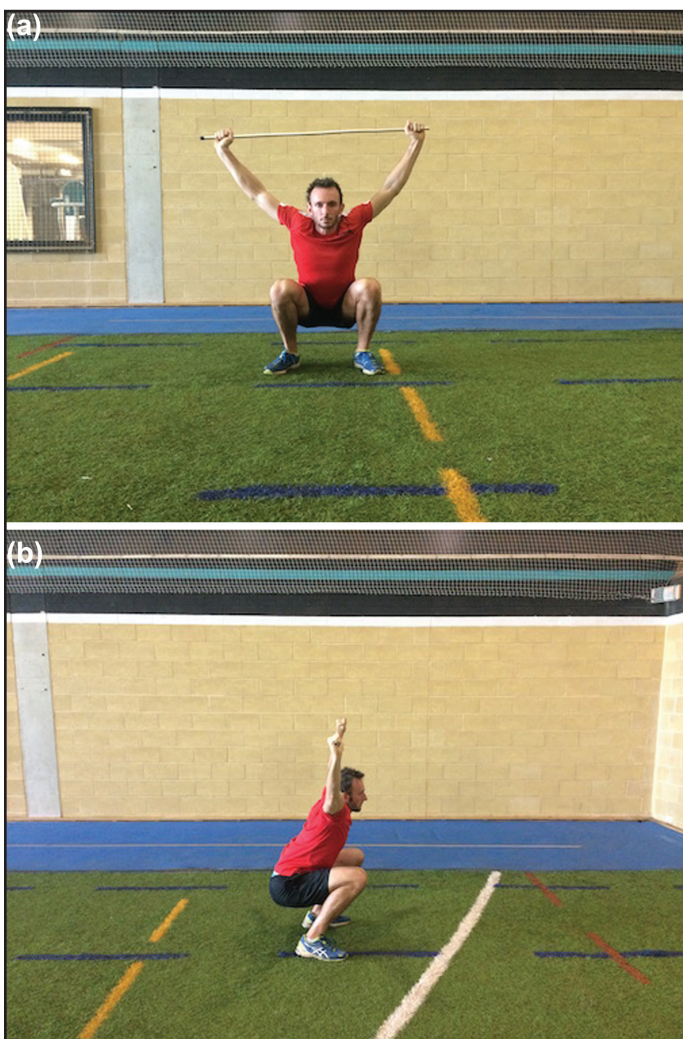


Figure 3. *Overhead squat, a) frontal view, b) side view*

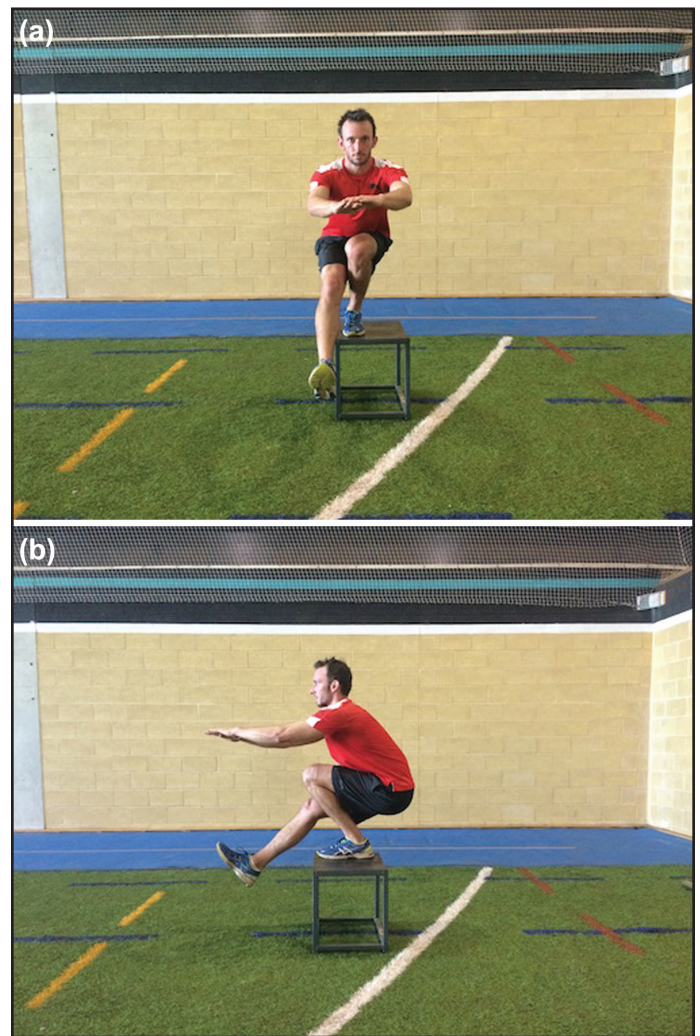


Figure 4. *Single leg squat, a) frontal view, b) side view*

assessment; this included bodyweight movements and mobility exercises (e.g. Squat, walking lunge, leg swings, mountain climbers). Feedback during the task was prohibited. Time to complete the full movement assessment varied depending on group numbers but typically takes from 20 minutes for two athletes to 60 minutes for a group of 10. The session was video taped using a standard two-dimensional camera placed in the optimal position for assessment depending on the specific exercise in question. This was typically performed in either the frontal or sagittal plane; however the overhead squat, single leg squat, and walking lunge exercises were filmed in both planes. Scoring was conducted in real-time by the primary researcher and re-scored from the video three months later. The same researcher re-scored the video again after seven days for the calculation of the video-based intra-tester reliability. To esti-

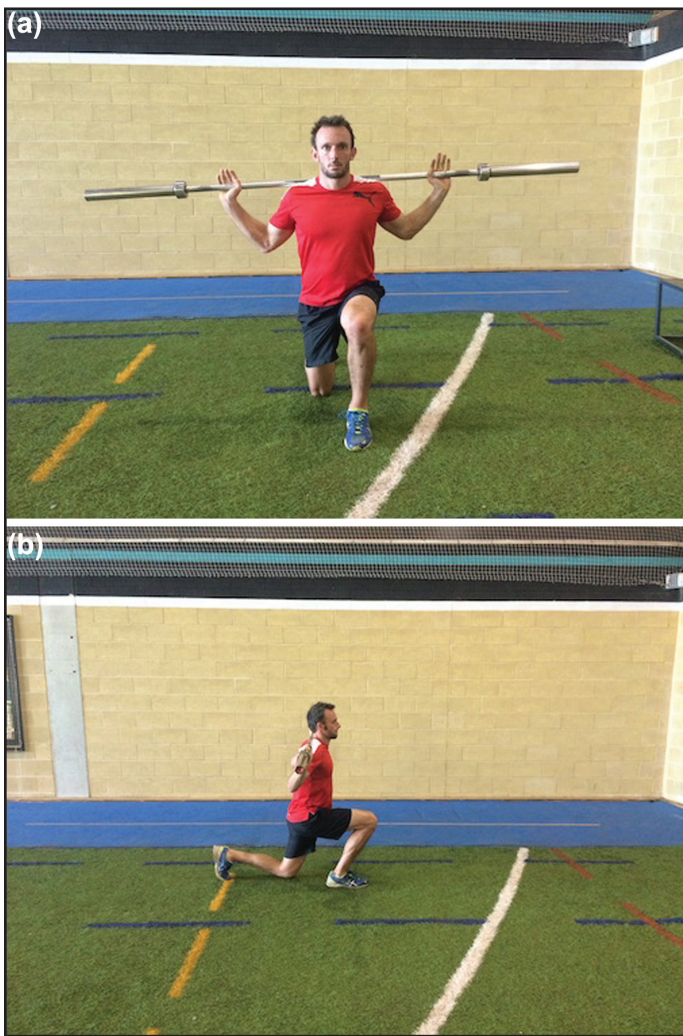


Figure 5. Walking lunge, a) frontal view, b) side view

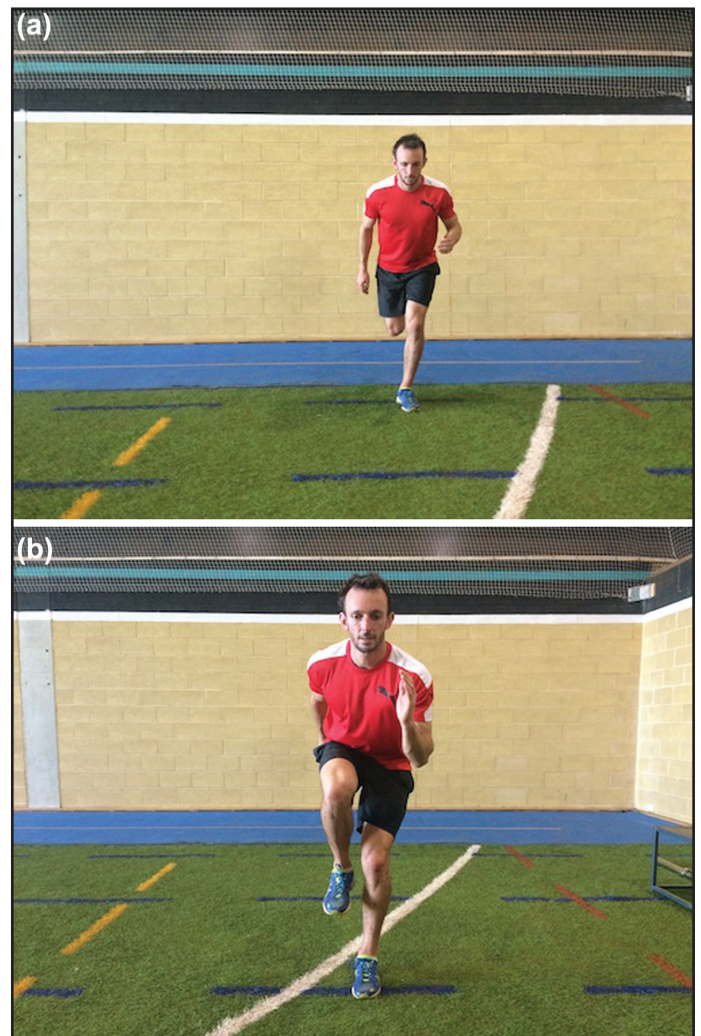


Figure 6. Single leg hop, a) start position, b) finish position

mate inter-tester reliability of the AAA scores, five other testers scored each athlete from the video footage. The testers were given a brief explanation of the scoring criteria for each movement and were provided with the scoring instructions as per Appendix 1. Each tester was instructed they could watch each clip as many times in real-time and slow motion as they deemed necessary before recording their score.

All descriptive data are presented as mean \pm standard deviation and where appropriate, reliability estimates are presented with their 90% confidence limits (CL). Minimal detectable change (MDC) and two-way mixed single intraclass correlation coefficient (ICC; 3, 1) were used to determine the intra and inter-tester reliability of the composite AAA score. Moreover, the intra and inter-tester reliability of each assessment

point within each exercise was assessed. Specifically, the intra-tester reliability of each assessment point was measured through the use of a two-way mixed single ICC (3, 1), while the inter-tester reliability was measured through the use of a kappa statistic. The mean values for each movement were then reported. The researchers interpreted the ICC reliability according to the following criteria: high reliability, 0.90–0.99; good reliability, 0.80–0.89; fair reliability, 0.70–0.79; poor reliability, 0.00–0.69.¹⁸ The level of agreement for the kappa statistic is as follows, < 0 less than chance agreement, 0.01–0.20 slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement, 0.81–0.99 almost perfect agreement.¹⁹ Finally, Pearson's correlation coefficients were used to estimate the agreement between the real-time and video-based scoring procedures.

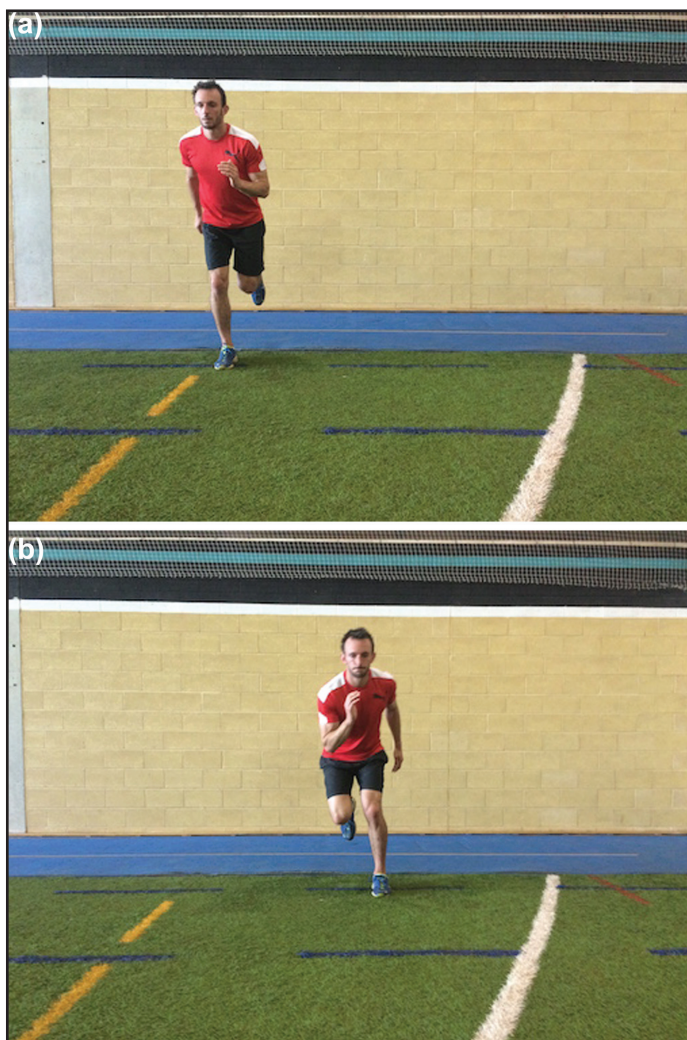


Figure 7. Lateral bound, a) start position, b) finish position

RESULTS

The mean composite score given by the primary researcher (Tester A) in real-time was 76 ± 13 (mean \pm SD) points (Table 1). The mean score based on video analysis was 72 ± 13 points on the first occasion and 72 ± 16 points on the second occasion. The mean change score for each subject was -0.1 ± 4.2 .

The MDC values are presented in Table 2. The intra-tester MDC for the composite score was 2.9 points (90% CI; 2.3 – 4.2) with an intra-tester ICC of 0.97 (0.92 – 0.99). The intra-tester MDC for each of the exercises ranged from 0.4 to 1.1 points. The inter-tester MDC for the composite score was 2.8 points (2.5 – 3.3) with an inter-tester ICC of 0.96 (0.94 – 0.98). The inter-tester MDC for each of the exercises was similar to the intra-tester MDC ranging from 0.4 – 1.0 points. The average intra and inter-tester reli-

ability for each coaching is presented within Table 3.

The correlation between real-time and video scores was excellent ($r=0.94$) with a MDC of 3.3 points (90% CI; 2.6-4.7). The exercises with the greatest amount of error between real-time to video were overhead squat 1.2 points (1.0 – 1.8) and walking lunge 1.2 (1.0 – 1.8).

DISCUSSION

Movement ability is an often-overlooked component of sport performance research and needs to be considered alongside the appraisal of physical fitness and performance characteristics.⁷ To achieve this, a standardised assessment tool is required. To date there has been debate over the appropriate tool to use to assess movement ability.¹² The authors have proposed a reliable alternative to previously published screening or assessment tools. An aim of the AAA is to enable the measurement of movement to be consistent in the literature and therefore be able to be considered alongside the investigation of physical fitness and performance characteristics in the future.

In this study the authors' have introduced the AAA for athletes and provided data supporting the scoring test-retest reliability. The results showed similar values for intra- and inter-rater reliability for composite and singular movement scores (Tables 2 and 3). Specifically, the AAA composite score credited to each athlete varied by approximately ± 3 points when scored by the same tester on different occasions, or when scored by different testers. This equates to an error of approximately 4%, which is similar to the MDC for inter-tester reliability of the FMS™ reported by Klusemann,²⁰ but lower than the 9.6% reported for a modified nine-test version of the FMS™ by Frohm.²¹ The MDC has not been commonly reported in other studies investigating the reliability of movement assessment tools.²²⁻²⁴ The intra- and inter-rater ICC values in this study for composite score were 0.97 and 0.96 respectively, which are better than reported for the FMS™ (0.75-0.95).^{20-22,24} The intra-tester reliability ranged from fair ($\kappa = 0.32$) to substantial ($\kappa = 0.77$), while the intra-tester reliability ranged from 0.57 to 0.81; both of which add support toward the use of the AAA as a reliable assessment tool. To improve the intra-tester

Table 1. Mean test scores for each tester in each condition (mean +/- SD).

Tester	Real time			Video			
	A	A(1)	A(2)	B	C	D	E
Composite score	76±13	72±13	72± 16	69±12	69±14	72±13	70±12
Prone hold	7.9±1.0	8.6±0.7	8.5±0.8	8.1±0.6	8.5±0.8	8.6±0.7	8.6±0.6
Side hold (left)	6.4±1.6	6.1±0.9	6.3±1.0	5.9±1.0	6.3±1.0	6.1±0.8	6.3±0.8
Side hold (right)	7.1±1.2	6.3±0.8	6.3±1.0	5.8±1.2	6.3±1.0	6.3±0.8	6.3±0.8
Overhead squat	7.3±1.5	7.2±1.6	7.2±1.7	7.1±1.5	7.2±1.8	7.2±1.6	7.0±1.5
Single leg squat (left)	7.9±1.4	7.4±1.3	7.1±2.3	6.9±1.5	7.1±3.2	7.5±1.1	7.4±1.3
Single leg squat (right)	7.1±1.5	6.8±2.4	7.2±1.5	6.5±2.2	6.6±1.2	6.7±2.3	6.5±2.3
Walking Lunge	7.2±1.7	7.1±1.5	7.1±1.5	7.0±1.3	6.4±1.5	6.9±1.5	6.6±1.5
Hop (left)	7.2±1.5	7.1±1.4	7.3±1.2	6.7±1.3	6.2±1.4	7.0±1.3	6.5±1.4
Hop (right)	7.3±1.4	6.7±1.4	6.8±1.7	6.8±1.0	6.4±1.5	6.7±1.2	6.2±1.4
Bound (left)	7.1±1.6	6.9±1.4	6.6±1.7	6.4±1.3	6.3±1.4	7.0±1.4	6.3±1.5
Bound (right)	7.3±1.6	6.8±1.2	6.5±1.7	6.2±1.2	6.5±1.5	6.6±1.4	6.4±1.4

reliability the authors suggest that experienced raters carry out AAA. The level of variation between inexperienced raters for movements with greater number of subjective assessment points could decrease the level of agreement as their assessment skills may be undeveloped.

While the ICC and kappa statistic provide a good indication of the relative reliability of the test scores (whereby high values show individuals are ranked similarly between conditions), the MDC is more useful for interpreting the changes in performance from test to test. In this case changes greater than the MDC of ± 3 points can confidently be interpreted as 'real' improvements, since the observed change is greater than the minimal detectable change in the test. The authors' recommend that future studies examining the reliability of movement assessment protocols include the MDC associated with the scores.

The MDC values were generally similar for all movements comprising the AAA, ranging from 0.4 to 1.1 points per movement in the intra-rater analysis and 0.4 to 1.0 points for the inter-rater analysis (Table 1). While the authors' suggest that it is preferable to

use the composite score when assessing changes in overall athletic ability, the results indicate that 'real' changes in specific exercises can be revealed when changes of more than 1 to 1.5 points are observed (based on the average width of the confidence limits across exercises). In contrast to values of MDC, the ICC and kappa values were not similar across all movements, with some low (poor) ICC values observed (e.g. prone hold) and fair levels of agreement in hops and bounds for kappa values. The authors' attribute the poor agreement in ICC values to small between-athlete variation in the performance of these movements. To illustrate, the individual scores for the prone hold ranged between 6 – 9 points, with 13 out 17 athletes scoring the maximum 9 points in the real-time assessment. Such a low variation in scores can mean that a change of only 1 point from test to test can greatly affect the ranking of an athlete within the group, resulting in a low agreement value. This is another limitation of relying solely on the ICC to indicate reliability of movement assessment scores.

Obtaining an estimate of the minimal detectable change is the first step in the validation of this

Table 2. Intra- and inter-tester minimal detectable change results. Values in brackets represent the 90% confidence intervals.

	Intra-tester	Inter-tester
	MDC	MDC
Composite score	2.9 (2.3 – 4.2)	2.8 (2.5 – 3.3)
Prone hold	0.6 (0.5 – 0.9)	0.6 (0.5 – 0.7)
Side hold (left)	0.7 (0.5 – 1.0)	0.6 (0.5 – 0.7)
Side hold (right)	0.4 (0.3 – 0.6)	0.4 (0.3 – 0.5)
Overhead squat	0.9 (0.7 – 1.3)	0.6 (0.5 – 0.7)
Single leg squat (left)	0.7 (0.5 – 0.9)	0.6 (0.5 – 0.7)
Single leg squat (right)	0.8 (0.6 – 1.2)	0.7 (0.6 – 0.9)
Walking Lunge	1.0 (0.8 – 1.4)	1.0 (0.8 – 1.1)
Hop (left)	0.8 (0.6 – 1.2)	0.8 (0.7 – 0.9)
Hop (right)	1.1 (0.9 – 1.6)	0.9 (0.8 – 1.1)
Bound (left)	0.6 (0.5 – 0.9)	0.6 (0.5 – 0.7)
Bound (right)	0.9 (0.7 – 1.2)	0.8 (0.7 – 1.0)

Table 3. The average intra- and inter-tester reliability for each coaching element within each movement of the AAA.

Exercise	Intra-Scorer (ICC)	Inter-Scorer (κ)
Prone Hold	0.60	0.77
Lateral Hold (L)	0.53	0.60
Lateral Hold (R)	0.81	0.71
Overhead Squat	0.90	0.77
Single Leg Squat (L)	0.75	0.53
Single Leg Squat (R)	0.80	0.58
Lunge	0.65	0.36
Hop (L)	0.57	0.39
Hop (R)	0.64	0.33
Bound (L)	0.76	0.60
Bound (R)	0.68	0.52

the case when performance can be assessed post-hoc via video analysis. The authors' have demonstrated that reliable AAA composite and individual movement scores can be obtained by a single-rater on different occasions and by different testers performing the same assessment, however future studies need to assess the amount of within-subject error introduced by the same athletes performing the assessment over time. This will enable a more accurate estimate of the changes that are likely to occur from test to test by chance alone. In the case of movement assessments, some reliability studies have included within-subject error^{18,20,21} while others have not.^{22,24} Care therefore must be taken when comparing the reliability estimates, and the methodology as a whole, between studies that are not comparable in their approach. Assessing the within-subject error is the next step in understanding the magnitude of change in AAA scores that represent real and important changes in individuals.

Relying on real-time assessment can be labor intensive when using a single tester and is often impractical with large groups. Videoing of exercises can alleviate the burden placed on the tester as well as provide video footage for future reference and additional scrutiny. Examining the relationship between

new assessment tool. This study was specifically designed to evaluate the random error of measurement and therefore the minimal detectable change²⁵ introduced to the AAA score by the practitioner(s) doing the scoring. In the intra-rater analysis this error arises from differences in the scores given by the primary researcher (Rater A) when scoring the same performance on two separate occasions. Since video footage of the performances was used, this estimate of random error is independent of any biological error (within-subject error) that would be observed if the same athlete completed the assessment on two different occasions. The exclusion of biological error is a strength of this study design. In many tests of human performance it is often difficult to separate these two components of error and therefore only one estimate of error is used to represent both (i.e. the error from the tester or equipment and the biological error from the athlete). This is not

the two scoring conditions is important. The analysis of the relationship between scoring in real-time and via video showed a very strong correlation. The MDC of 3.3 points for the composites score is similar to the other values reported in this study. This analysis supports the use of real-time and video assessment as relatively similar. This clarity in scoring difference provides confidence that an alternative observation will provide reliable results.

This study utilised a small, homogenous – single sex, single sport subject group and a small rater group, in order to strengthen the methods used for this initial assessment of the AAA. Future studies should address these weaknesses of the study design using different sporting groups, male athletes, and various levels of athletes. Along with obtaining estimates of within-athlete error, further studies have been planned by the current group to investigate the relationship between changes in AAA and athletic performance, furthering the understanding of the smallest worthwhile change in AAA that is meaningful for both physical and on-field performance enhancement. An exploration of the relationship of AAA scores and injury risk is also needed.

CONCLUSIONS

The AAA has been developed to meet the needs of practitioners working with athletic populations. The results from intra- and inter-tester analyses show that the scores are reproducible in female football athletes based on video and real-time assessments. The MDC in each circumstance is approximately three points. Based upon these estimates, changes in AAA scores greater than three points can be considered to represent 'real' change. Testers of movement assessment should ideally establish their own MDC as was illustrated in this study. These initial stages in the validation of the AAA are essential for future examination of the relationships between movement ability, injury risk, and sports performance. To date this relationship is incompletely described, but remains a commonly accepted training concept in contemporary strength and conditioning, and therefore more research is needed in this area.

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Appendix 1. Athletic Ability Assessment - Exercises, rationale and scoring criteria.

Exercise	Selection Rationale	Assessment Points	Score		
			3	2	1
Prone Hold on hands 2 min (Figure 1a & 1b)	Isometric hold linking upper body, trunk and lower body. The ability to maintain neutral alignment throughout body enables the coach to assess scapular positioning under load and hip stability and control under tension. Being able to stabilise and control trunk integrity is a cornerstone to all subsequent actions in sport and movement.	Upper back/shoulder position	Scapula depression and retraction constant for 2 min No protraction or elevation of scapular	Inconsistent positioning (repositioning) throughout the 2 min	Unable to attain correct position
		Hip position	Neutral hip positioning with no anterior/posterior tilt or rotation	Inconsistent positioning (repositioning) throughout the 2 min	Unable to attain correct position
		Time	> 2 min	1-2 min	< 1 min
Lateral Hold on hands Left and Right Sides 2 min (Figure 2)	Lateral stabilisation illustrates ability of lateral structures to control body weight with correct trunk, hip and shoulder position. This is particularly important in sports where the athlete has to control body weight in multiple directions	Upper back/shoulder position	Scapula depression and retraction constant for 2 min No protraction or elevation of scapular	Inconsistent positioning (repositioning) throughout the 2 min	Unable to attain correct position
		Mid-line alignment	Able to maintain full mid-line alignment with no rotation or side flexion through trunk or hips	Inconsistent positioning (repositioning) throughout the 2 min	Unable to attain correct position
		Time	> 2 min	1-2 mins	< 1 min
Overhead Squat 10kg Olympic Bar x 5 repetitions (Figure 3a & 3b)	Squat movement with overhead position of arms, with load, highlights strength of upper body to hold this position along with compensatory patterns through shoulder/arm/thoracic spine to cope with this position and load whilst also assessing lower body mobility and strength.	Hands/Bar Overhead	Maintains bar overhead with appropriate shoulder/thoracic extension & trunk angle with no rotation	Bar over mid-foot but incorrect movement patterning	Excessive or inappropriate trunk inclination
		Hip/Knee/Ankle Alignment	Perfect alignment and control of hip/knee/ankle throughout every rep	Inconsistent form with some perfect reps OR minor misalignment on all repetitions	Unable to attain correct position
		Depth	Hip below knee (below parallel) while maintaining neutral spine for all repetitions	Depth beyond parallel for some but not all reps	Not able to achieve required depth for any reps
Single Leg Squat off box Left and Right Sides x 5 repetitions (Figure 4a & 4b)	Single leg ability is critical as a foundation skill for locomotive movements in a majority of sports. SL Squat has the ability to bring to light a range of coordination, proprioceptive, strength and mobility deficiencies in a unilateral environment. The ability to SL squat in a controlled environment indicates movement efficiency to progress training load to include more complex technical abilities.	Trunk angle	Maintains perfect trunk posture for all reps	Inconsistent or uncontrolled forward lean and/or movement from neutral lumbopelvic position	Excessive and uncontrolled forward lean and/or movement from neutral lumbopelvic position
		Hip/Knee/Ankle Alignment	Perfect alignment and control of hip/knee/ankle throughout every repetition	Inconsistent form with some perfect repetitions OR minor misalignment on all repetitions	Poor alignment throughout
		Depth	Hip below knee (below parallel) while maintaining neutral spine for all reps	Depth beyond parallel for some but not all reps	Not able to achieve required depth for any reps
Walking Lunge 20kg Olympic Bar x 10 steps (Figure 5a & b)	Lunge positions incorporate hip mobility, trunk stability, strength, and motor control in one exercise. The complex interaction of these components illustrates dysfunctional patterns or components of athletic movement.	Knee/Ankle Alignment	Perfect alignment and control of knee/ankle throughout every rep	Inconsistent form with some perfect repetitions OR minor misalignment on all repetitions	Poor alignment throughout
		Hip Control	Perfect alignment of hips throughout	Inconsistent form with some perfect reps OR minor loss of control on all reps	Excessive loss of control from neutral throughout the movement

Appendix 1. Athletic Ability Assessment - Exercises, rationale and scoring criteria. (continued)

		Trunk Control	Maintain neutral spine throughout No forward or side flexion/movement	Inconsistent form with some perfect reps OR minor loss of control on all reps	Forced lumbar extension or lack of trunk control during force production
Single Leg Forward Hop Left and Right Sides x 3 repetitions (Figure 6a & b)	The capability to reduce and stabilise forces in a unilateral environment is critical for change of direction and multi-sprint ability in many sports and training modalities. Being able to reduce force and stabilise efficiently not only quickens the ability to change direction and therefore increasing sporting performance, but efficiency through this movement is likely to reduce risk of noncontact injury incidence. SL power production is also a key component of acceleration in sport.	Hip/Knee/Ankle Alignment	Perfect alignment of hip/knee/ankle	Inconsistent form with some perfect reps OR minor misalignment on all reps	Poor alignment throughout
		Balance/Control	Landing with perfect balance and control	Sticks landing but is unbalanced. Adjustments made via other body movements	No balance/control on landing
		Power Position on Landing*	Lands in Single Leg power position/quarter squat after every rep	Inability to land in power position on some but not all reps OR makes adjustments post landing to attain power position	Excessive hip/knee/ankle flexion. Poor positioning to reproduce force.
Lateral Bound Left and Right Sides x 3 repetitions (Figure 7a & b)	Lateral bound and stick progresses the SL hop to mimic the forces produced to change direction. Change of direction and rotational forces confound the risk of injury, particularly of non-contact injury and especially in females. For an athlete to perform agility or change of direction drills and sports safely, lateral bound and stick ability has to be correct.	Hip/Knee/Ankle Alignment	Perfect alignment of hip/knee/ankle	Slight deviation from ideal landing alignment	Poor alignment throughout
		Balance/Control	Sticks the landing with perfect balance and control	Sticks landing but is unbalanced. Adjustments made via other body movements	No balance/control on landing
		Power Position on Landing*	Lands in Single Leg power position/quarter squat after every rep	Inability to land in power position on some but not all reps OR makes adjustments post- landing to attain power position	Excessive hip/knee/ankle flexion. Poor positioning to reproduce force.
Push ups	The ability to move and control bodyweight is vital for many	Scapulohumeral	Scapula depression	Inconsistent	Poor scapula
Minimum repetitions = 20 reps (males), 12 reps (females)	sports and training environments. This ability should incorporate correct movement mechanics of the upper body, particularly scapula and trunk position and synchronicity of movement.	rhythm	and retraction constant throughout movement No protraction or elevation of scapular or flaring of elbows	form. Some perfect reps.	positioning and control for all reps
		Body Control	Perfect body control and alignment for every repetition	Perfect body control and alignment for some but not all reps	Poor body control and/or alignment for all reps
		Complete repetitions	M ≥ 20 F ≥ 12		M < 20 F < 6
Chin ups Minimum reps = 10 repetitions (males), 4 repetitions (females)	Pulling strength and control is vital for good long term shoulder health and a sound indicator of upper body strength. Chin Ups should highlight gross upper body pulling strength. Chin Ups will also indicate sound scapula rhythm and muscle recruitment patterns in a vertical direction under bodyweight load.	Scapulohumeral rhythm	Scapula depressed and retracted throughout hang. Symmetry of scapulohumeral rhythm during pull and lowering phase of exercise. No scapula elevation or winging.	Inconsistent form. Some perfect repetitions OR slight asymmetry	Poor scapula positioning and control for all repetitions
		Body Control	No swinging. Perfect body control for all repetitions	Perfect body control for some but not all repetitions	Poor body control and/or alignment for all repetitions
		Complete repetitions	M ≥ 10 F ≥ 4		M < 10 F < 4
* ‘Power’ position is defined as the optimal individual body position resulting from appropriate reduction and stabilization of forces through the lower body and is commonly used as a coaching point for landing and jump technique. The additional elements of balance and trunk position are included in this definition to fully assess the body’s ability to reduce and stabilise throughout the full kinetic chain. This body position definition is applicable to bilateral and unilateral positions.					